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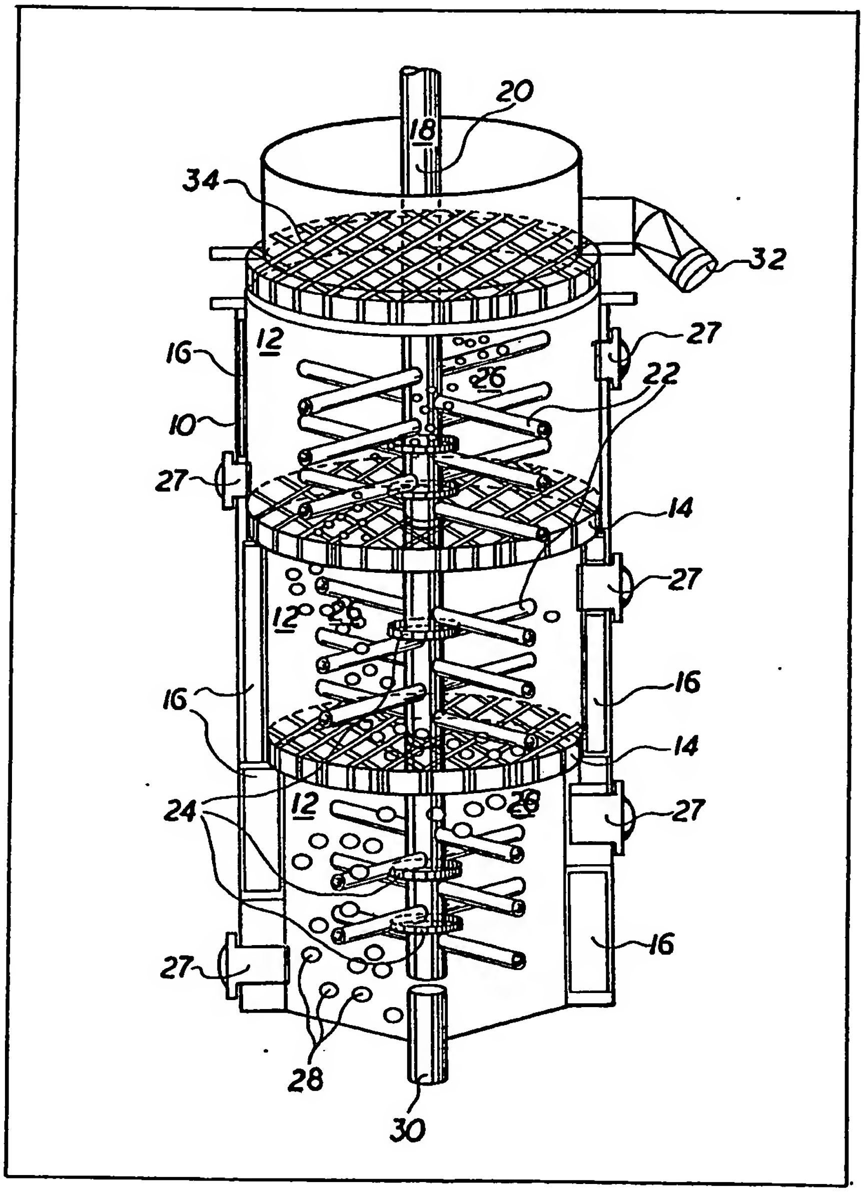
(54) Agitator-media comminuting device

(57) A compartmented agitator mill comprises a comminuting vessel (10); comminuting media (28) e.g. comminuting elements of different sizes contained within the comminuting vessel; an agitator (18) extending into the comminuting media and being rotatable therein, the said agitator having a central shaft (20) and agitator arms (22) extending therefrom. Grids (14) separate the said comminuting vessel into the compartments (12) containing a portion of the said comminuting media, the said agitator extending into each of said compartments.



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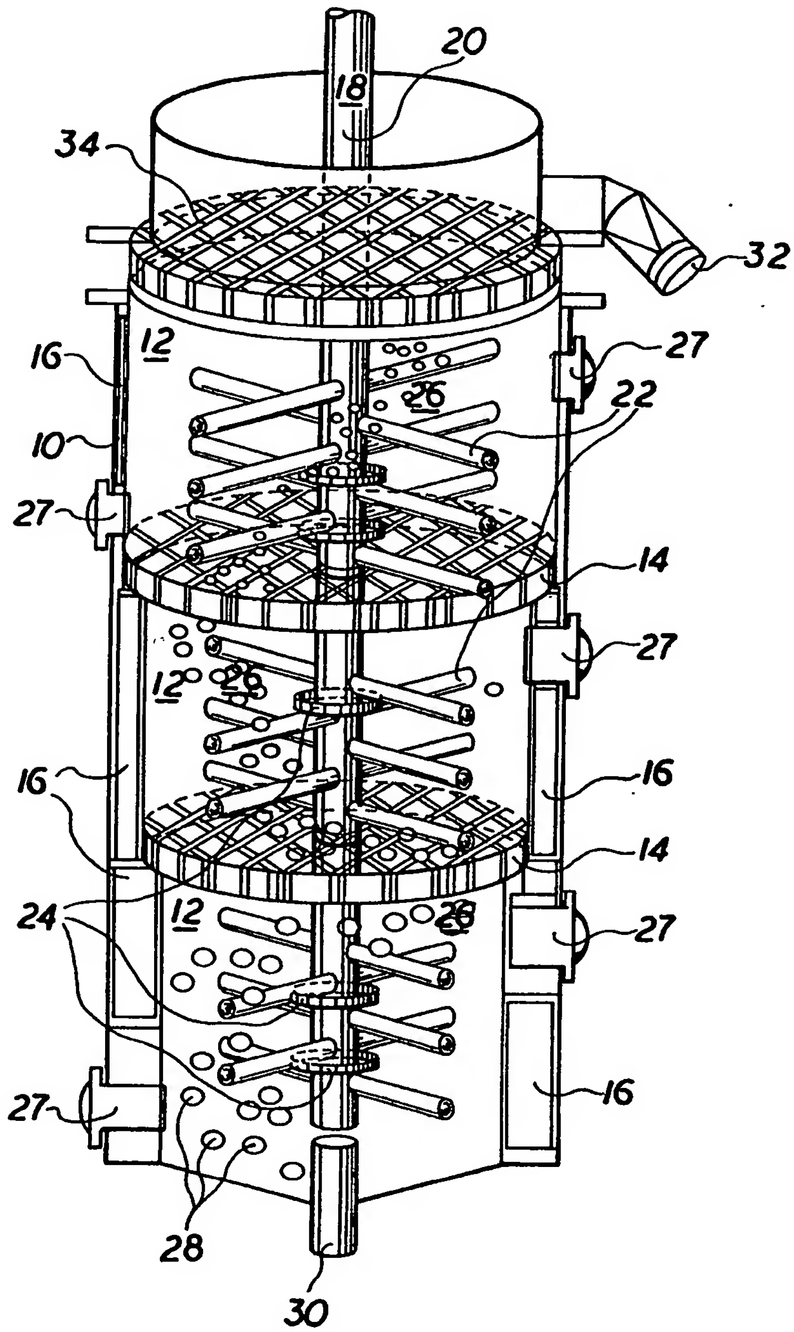

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SPECIFICATION
Agitated-media comminuting device

The subject application is directed to apparatus for processing minerals, and more particularly to an agitated-media comminuting device.

Comminution of certain minerals to a particle size in the range of 100 to 400 mesh and finer has been found to provide substantial improvements in the use of such minerals and, in some cases, even new uses for the minerals. However, apparatus for processing the minerals to a sufficiently fine degree and at a commercially acceptable rate have not been available.

For example, it is known that if coal is processed to a sufficient fineness, it can be generally freed from sulphur and ash impurities. It has now been found that when coal particles are further reduced to less than about 3 microns, they can be included in combustible mixture that can be used directly as a fuel for boilers or even internal combustion engines. Many coal processing devices were known in the prior art. However, the various grinders, mixers, dryers and other devices known in the prior art as shown in 241,653; 1,577,052; 975,380; and 2,168,093 would not comminute the coal to a sufficiently fine degree so that the coal could be used as a fuel for boilers or for gasoline and diesel engines. Ball mills and related horizontal mills and related horizontal mills such as shown in US Patents 639,405; 1,986,103; 2,822,987; 3,056,561; 3,223,336; and 3,682,399 provided a sufficiently fine product, but were too slow or inefficient to be useful in a commercial processing system.

Agitated-media comminuting mills have been found to be effective in processing coal and other minerals to a fine particle size. Agitated-media comminuting mills are distinguished from ball mills, pebble mills, roll mills, sand mills, table mills, and the like. Agitated-media mills include a vessel that contains a bed of comminuting elements that are agitated by members connected to a rotating shaft. Examples of agitated-media mills are discussed in British Patent Nos. 716,316; and 1,331,662; and German Patentschrift Nos. 1,214,516 and 1,233,237; and US Patent Nos. 2,764,359; 2,779,752; 3,008,657; 3,018,059; 3,131,875; 3,149,789; 3,204,880; 3,332,628; 3,493,182; 3,502,396; 3,601,322; 3,799,455; 3,998,938; and 4,244,531. Typically, the solid particles are ground to a particle size in the range of 50 to 0.05 microns and, in certain instances, the particles are ground even smaller. A substantial advantage of the agitated-media type comminuting mills, as compared to vibratory mills for example, is that comminution occurs primarily between the comminuting elements of the agitated media and does not involve the vessel walls. Consequently, mechanical wear of the agitator shaft and the inner wall of the vessel is considerably reduced. Another advantage of agitated-media type comminuting mills is that the comminuting vessel remains stationary so that these mills are less cumbersome than vibratory type mills.

Generally, agitated-media comminuting mills are described as batch-type, circulation-type, or continuous-type mills. In a batch-type mill, such as described in US Patent No. 2,764,359, a selected quantity of a process mixture is placed in a vessel together with the comminuting media and the comminuting media is then agitated by an agitator. The comminuting media is agitated until the mixture is ground, dispersed and/or deflocculated as required. When the mixture is sufficiently comminuted, the batch-type comminuting mill is stopped and the processed comminuted material is removed.

The continuous-type agitated-media comminuting mill such as described in US Patent No. 3,149,789 is somewhat similar to the batch-type mill except that the mill is more elongated and the process mixture is steadily introduced to the comminuting vessel at one end and the comminuted mixture is removed at the opposite end. Usually, the mixture is introduced at the bottom of the vessel and removed from the top of the vessel with the vertical progression of the mixture through the vessel being horizontally stratified such that the particle density and size distribution of the mixture remain substantially the same at each level of the vessel.

In circulation-type agitated-media comminuting mills such as described in US Patent No. 3,998,938, the comminuting vessel is somewhat similar to that of the batch-type mill but the process mixture is repeatedly recirculated at a high flow rate through the comminuting vessel as the mixture is being comminuted. The high flow rate, sometimes referred to as "steaming speed", together with the recirculation of mixture results in an unexpectedly rapid comminution of the mixture and provides a product with a narrow particle size distribution.

Although agitated-media devices could generally process small amounts of coal to a small size and at a sufficiently high rate, the physical limitations of prior agitated-media mills are such that they could not be made large enough to process coal or other minerals on a commercial scale. As the agitated-media devices were made larger, the pressure of the media in the lower region of the vessel became so great that the horsepower requirements for the mill became very high. Moreover, the effectiveness of the activated-media was itself adversely effected. To the extent that the problem was recognized, the prior art such as US Patent 3,670,970 tended to lead away from the present invention by teaching that the vessel should be made very low in comparison to its height and the grinding media should be made low in proportion to its width.

Accordingly, there was a need in the prior art for an agitated-media mill that could grind quantities of coal or other minerals to a higher degree of fineness than heretofore attainable by known devices.

In accordance with the subject invention, an agitated-media comminuting device includes a

comminuting vessel that contains a media of comminuting elements. A plurality of grids located cross-sectionally within the comminuting vessel separate the vessel into a plurality of compartments, with a portion of the comminuting media located in each compartment. An agitator having a central shaft and radially extending arms extends into the comminuting vessel, through the grids, and within the comminuting media in each of the separate compartments such that the comminuting elements are excited by rotation of the agitator. In certain cases, the comminuting media includes comminuting elements of a plurality of sizes with the elements of each particular size being located together in a respective vessel compartment.

Preferably, the agitator is further provided with discs located around the central shaft and each vessel compartment is provided with a separate media port. Also preferably, the comminuting vessel further includes temperature control apparatus for example a water jacket, for individually controlling the temperature in each of the vessel compartments.

The invention is hereinafter described in more detail, with reference to the accompanying drawing which is an elevation cross-section of a preferred embodiment of a comminuting device in accordance with the invention.

As shown in the drawing, the device includes a comminuting vessel 10 that is divided into a plurality of vessel compartments 12 by grids 14. Vessel 10 is generally cylindrical with the height about three to six times its diameter. Preferably, vessel 10 is provided with a means for heating and cooling such as water jackets 16. More preferably a separate water jacket 16 is provided corresponding to each of vessel compartments 12.

The embodiment shown further includes an agitator 18 having a central shaft 20 with arms 22 extending therefrom. Preferably, arms 22 are normal to central shaft 20 and have substantially even vertical distribution along shaft 20. Also preferably, arms 22 are of different lengths as measured from shaft 20 with an arm on one side of shaft 20 being longer than the arm oppositely disposed on shaft 20. As shown in the drawing, arms 22 have a circular cross-sectional shape. However, arms with other cross-sectional shapes can also be used. In the preferred embodiment, vertically adjacent arms are disposed at an angle of about 90 degrees with respect to each other. Alternatively, the arms can be disposed at other angles for particular applications. For example, where the mixture is to be processed through the mill at a relatively rapid rate, it is preferred that a vertically adjacent arm on one side of a particular arm be at an angle of about 2.5 degrees while the arm on the opposite side be at an angle of about 60 degrees. In each case, the particular arrangement is selected to increase the hydrodynamic effect of the agitator 18 on the process mixture. Agitator 18 if further provided with discs 24 are located concentrically around shaft 20 and are disposed between agitator arms 22.

The device shown also includes comminuting media 26 comprised of a multiple of comminuting elements 28 such as ceramic or metal balls. Preferably, comminuting elements 28 are spherical and generally have a diameter in the range of about 9/16 inch (1.42 cm) to 1/8 inch (3.17 mm), although smaller or larger comminuting elements may also be used depending on the viscosity of the process mixture, the rated angular velocity of shaft 20, the size of comminuting vessel 10 as well as other variable parameters.

Comminuting media 26 is divided among each of vessel compartments 12. For some applications, comminuting elements 28 are of a substantially constant diameter and are proportionately located in each of vessel compartments 12. For other applications, comminuting media 26 is comprised of comminuting elements of a plurality of sizes with the elements of a particular size located in a respective one of vessel compartments 12 with the comminuting media disproportionately distributed among vessel compartments 12. Preferably, when comminuting media 26 includes elements of different grade sizes, the grade sizes are arranged in vessel compartments 12 in progressively smaller order from the bottom of vessel 10 toward the top thereof. In this case, the comminuting media 26 is disproportionately distributed with about 2% to 35% of the total of the comminuting elements being located in the lowermost vessel compartment and about 20% to 90% of the total of the comminuting elements being located in the uppermost vessel compartment. This arrangement of comminuting media 26 has been found to provide improved comminution in that the output product achieves a finer particle size in a substantially shorter time. Vessel 10 is provided with media port 27 corresponding to each vessel compartment 12 by which the media 26 may be placed into or taken out of the respective compartment. Preferably, two media ports 27 are provided corresponding to each compartment, one port being provided in the upper region of the compartment to introduce the media and one port being provided in the lower region of the compartment to remove the media.

The comminuting media includes a sufficient number of comminuting elements 28 such that, at times when agitator 18 is stationary and comminuting elements 28 are in an unagitated state, the comminuting elements 28 in each of the vessel compartments 12 cover at least one of agitator arms 22. Greater numbers of comminuting elements 28 may also be used as, for example, where there are sufficient comminuting elements to cover the uppermost agitator arms 22 when the comminuting media is in an unagitated state. The most preferred number of comminuting elements depends on various parameters including the viscosity of the process mixture; the size, density and shape of the

comminuting elements; and the rated angular velocity of the agitator. Preferably, the vertical separation between vertically adjacent agitator arms 22 is in the range of two to four times the diameter of comminuting elements 28 although this also is variable depending upon the particular application.

Comminuting vessel 10 is provided with an input port 30 through which the process mixture is introduced to vessel 10 and an output port 32 through which the comminuted process mixture is removed after comminution is completed. Output port 30 is provided with a screen 34 or other suitable means for separating comminuting elements 28 from the comminuted process mixture.

In the operation of the illustrated embodiment, the process mixture is provided to input port 30 of comminuting vessel 10. Generally, the process mixture is comprised of an aqueous or oil mixture of the mineral to be ground, the mineral having been prepared in a crusher or similar device to an average particle size of about 75 microns (200 mesh) to 1000 microns (18 mesh) with the mineral concentration generally being about 20—50% by volume and 20—65% by weight.

Agitator 18 is rotated at an angular rate by a motor and speed reducer (not shown) such that agitator arms 22 agitate comminuting elements 28 and the effective or apparent volume of the comminuting media substantially increases and the comminuting elements are dispersed through the process mixture. Typically, the angular velocity of agitator 18 is in the range of 100 to 400 rpm such that the maximum speed at the distal ends of the arms 22 is about 600 to 1200 feet per minute. As the agitation of comminuting media 28 continues, comminuting elements 28 interact with each other to affect comminution of the process mixture.

It is believed that the improved comminuting performance of the batch, continuous, and circulation agitated-media mills is due to the action of the agitated media and, in particular, to the collisions between the comminuting elements. These collisions impinge on the solid particles of the process mixture causing the particles to be physically divided and sub-divided. Furthermore, it appears that, in certain instances, changes in the properties of the particle solids also occurs. This action of the agitated media has been variously described in connection with the kinetic energy of the comminuting elements and the mean free path between collisions of the comminuting elements. Indeed, the comminuting elements used in agitated-media comminuting mills are generally smaller than those employed in other types of mills in order to increase the rate of collisions between comminuting elements and, therebe, increase the rate of comminution.

Upon entering the comminuting vessel 10, the process mixture successively advances through the vessel compartments 12 in a steady upward flow. Discs 24 maintain the continuous advance of the process mixture by preventing channeling of the process mixture adjacent central shaft 20. Preferably, comminuting vessel 10 includes three to five vessel compartments 12 such that grids 14 limit the ball pressure in the lower regions of each of the separate portions of the media 26. Thus, the disclosed apparatus can be used for processing large commercial quantities of minerals in a single attritor device. At the same time, grids 14 reduce the size requirements for the motor and speed reducers that rotate agitator 18.

Water jacket 16 is divided into sections corresponding to each of vessel compartments 12 so that the process mixture can be heated or cooled as necessary to control the temperature thereof. In some instances, after start-up it is possible to use the exothermic condition of the upper vessel compartments 12 as a heat source to heat the lower vessel compartments 12 by circulating the cooling water from the upper sections to the lower sections. For example, in the processing of a coal-oil mixture, the lower-most compartment 12 may require heat in order to provide a sufficiently low viscosity to the process mixture, whereas, processing the same mixture in the upper-most vessel compartment 16 may require cooling in order to prevent the process heat from breaking down or decomposing the oil constituent. Since water jacket 16 is divided into sections, the water can be circulated from the upper-most section to the lower-most section to transfer the heat generated in the upper-most vessel compartment 16 to the lower-most vessel compartment 16.

The output product provided at port 30 is a mixture wherein the solid particles are approximately 75 microns (200 mesh) to 1 micron depending on the size and composition of the particular feedstock and the rate at which the process mixture progresses through vessel 10. The process time for the mixture is controlled by the feed rate and is generally in the range of about ten minutes to about two hours. The precise time for a particular application depends on the particle size of the input mixture, the particle size required for the output mixture, and the specific type of mineral being processed, as well as other factors.

While a presently preferred embodiment of the invention has been shown and described, the invention is not limited thereto, but other embodiments may be used within the scope of the following claims.

CLAIMS

1. An agitated-media comminuting device, comprising a comminuting vessel (10); a comminuting media (28) contained within the comminuting vessel; an agitator (18) extending into the comminuting media and being rotatable therein, the said agitator having a central shaft (20) and agitator arms (22) extending therefrom; characterized in that a plurality of grids (14) provided to separate the said comminuting vessel into compartments (12) containing a portion of the said comminuting media, the said agitator extending into each of said compartments.

2. A device according to claim 1, wherein the said comminuting media comprises a multiple of comminuting elements (28) of different sizes, elements of each size being contained in a particular compartment.

3. A device according to claim 1 or claim 2, wherein the said shaft is provided with discs (24) mounted thereon and extending between the said arms thereon.

4. A device according to any of claims 1 to 3, wherein the said comminuting vessel includes at least one port (30, 32) for process media.

5. A device according to any of claims 1 to 4, wherein at least one of the said compartments includes temperature control means (16) for controlling the temperature therein during use.

6. A device according to claim 5 wherein the said comminuting vessel includes a temperature control means for each of the said compartments, to control the temperature therein during use.

7. An agitated-media comminuting device according to claim 1, substantially as hereinbefore described with particular reference to the accompanying drawing.

New claims or amendments to claims filed on 4 Nov. 1983.

Superseded claims:— 1—7.

New or amended claims:—

1. An agitated-media comminuting device, comprising a comminuting vessel (10); a comminuting media (28) contained within the comminuting vessel; an agitator (18) extending into the comminuting media and being rotatable therein, the said agitator having a central shaft (20) and agitator arms (22) extending therefrom; a plurality of grids (14) to separate the said comminuting vessel into compartments (12) containing a portion of the said comminuting media, the said agitator extending into each of the said compartments: characterized in that the said comminuting vessel includes a temperature control means (16) for each of the said compartments, to control the temperature therein during use.

2. A device according to Claim 1, wherein the said comminuting media comprises a multiple of comminuting elements (28) of different sizes, elements of each size being contained in a particular compartment.

3. A device according to Claim 1 or Claim 2, wherein the said shaft is provided with discs (24) mounted thereon and extending between the said arms thereon.

4. A device according to any of the Claims 1 to 3, wherein the said comminuting vessel includes at least one port (30, 32) for process media.

5. An agitated-media comminuting device according to Claim 1, substantially as hereinbefore described with particular reference to the accompanying drawing.

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